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Original Scientific Article

Optimizing Performance: The Impact of a 10-Day High-Intensity Interval Training Protocol on Youth Athletic Performance

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Abstract

Objectives. This study aimed to examine the impact of a 10-day High-Intensity Interval Training (HIIT) protocol on the specific endurance of U16 female basketball players, focusing on improvements in aerobic and anaerobic capacity and performance in the Yo-Yo Intermittent Recovery Test Level 1 (YoYoRL1).

Materials and methods. Eight female U16 basketball players participated in the study, completing a 10-day HIIT program designed to enhance both general and sport-specific endurance. Pre- and post-training assessments included body composition measures (weight, BMI, body fat percentage) and the YoYoRL1 test to evaluate changes in performance. The training program incorporated various HIIT modalities, including full-body exercises, parkour circuits, and basketball-specific drills, with progressively adjusted work-to-rest ratios.

Results. The findings showed a substantial improvement in YoYoRL1 test performance from pre-test to post-test, with participants' mean scores increasing from 14.2 ± 1.2 in the pre-test to 16.5 ± 1.2 in the post-test ($p = .001$, $\eta_p^2 = .837$), highlighting a large effect size and strong statistical significance in the results. Body composition analysis revealed a slight increase in weight (64.3 ± 10.6 kg post-test) and a small reduction in body fat percentage (20.2 ± 4.1 % post-test), indicating favorable adaptations in muscle mass and fat distribution.

Conclusions. Implementing the 10-day HIIT protocol significantly improved specific endurance and aerobic capacity in U16 female basketball players, suggesting that short-term HIIT interventions can effectively enhance performance in youth athletes. These findings support the use of HIIT for optimizing endurance and recovery in basketball, with implications for developing time-efficient training protocols for young athletes. However, the study's small sample size and short duration limit the generalizability of these findings, necessitating further research with larger cohorts. Future research should focus on exploring such training program' long-term effects and applicability in various athletic populations.

Keywords: HIIT, Yo-Yo intermittent recovery test, endurance, female basketball, youth athletes.

Introduction

Basketball is characterized by short bursts of intense activity, often repeated at high frequencies throughout a game (Gottlieb et al., 2021). These unique physical demands require athletes to demonstrate mixed (complex) manifestations of aerobic and anaerobic abilities, enabling them to sustain high-intensity efforts and recover quickly between actions (Gottlieb et al., 2014). Research has shown that higher aerobic capacity is critical role in enhancing a player's ability to perform these intermittent efforts throughout a game and during training sessions (Gottlieb et al., 2021). Effective endurance allows players to recover more rapidly, ensuring they maintain performance levels during games and practices (Liu et al., 2024). Therefore, improving aerobic fitness is essential for optimizing basketball performance.

High-intensity Interval training (HIIT) involves repeated bouts of intense exercise, alternating with recovery periods of lighter activity or rest (Coates et al., 2023). Since a perceived lack of time is a major barrier to widespread

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participation in exercise programs, HIIT training is appealing because it offers a potentially more time-efficient way to achieve the adaptive benefits of exercise (Foster et al., 2015). When applied to athletes, HIIT induces physiological adaptations that enhance their ability to sustain high work intensities and resist fatigue during competition (Hung et al., 2025). Unlike traditional endurance training, which requires prolonged sessions, HIIT achieves similar or superior results in a shorter timeframe, making it a more practical option for young athletes with limited training time.

Interval training can be categorized based balancing between aerobic and anaerobic energy contributions. The intensity of the intervals, ranging from submaximal to all-out efforts, determines whether the workout emphasizes aerobic or anaerobic systems (Rosenblat et al., 2020). This differentiation allows for more specific targeting of physiological adaptations, with aerobic HIIT focusing on endurance and anaerobic HIIT enhancing power and speed (Jamnick et al., 2020).

HIIT elicits a range of physiological adaptations that enhance aerobic and anaerobic performance, closely aligning with basketball demands (Shamim, 2021; Tabata et al., 1996). Studies have shown that HIIT significantly improves cardiovascular endurance, power, change of direction ability, and sprint performance in basketball players (Shudian et al., 2025). Cardiovascular adaptations, such as enhanced cardiac contractility and capillary density, increase stroke volume, improving oxygen delivery and VO_2 max. Research indicates that HIIT can increase in stroke volume due to enhanced cardiac contractility and capillary density, contributing to improved aerobic fitness (Irawati & Boenyamin, 2019). Muscular adaptations include increased mitochondrial density (Chrøis et al., 2020). Metabolic improvements, such as enhanced insulin sensitivity, glycogen storage and lactate clearance, increase energy efficiency and fatigue resistance (Zheng et al., 2020; Xie et al., 2024). These adaptations make HIIT an effective, time-efficient training method for basketball players, supporting their ability to sustain high-intensity efforts and recover rapidly.

Sport-specific endurance training in basketball prepares the body's energy systems to efficiently handle the high-intensity actions required during a game. By mimicking basketball demands, HIIT enhances the aerobic system's capacity for recovery and the anaerobic system's ability to deliver quick bursts of energy (Edwards et al., 2018). This targeted approach improves overall endurance and develops stamina and fatigue resistance, which are crucial for maintaining peak performance throughout a basketball match's fast-paced and dynamic.

The Yo-Yo Intermittent Recovery Test Level 1 was developed to evaluate an athlete's ability to repeatedly perform high-intensity aerobic work and has become one of the most popular field tests for youth and recreational athletes (Schmitz, 2018; Bangsbo et al., 2008). It validates and reliably predicts high-intensity aerobic capacity and VO_2max across various sports and competition levels. It is an essential tool for coaches and trainers assessing endurance and performance potential (Schmitz, 2018; Bangsbo et al., 2008).

HIIT stands as the most renowned method for exceeding the fatigue threshold, however the risks associated with high intensity training lead to a hesitation among coaches and athletes regarding its implementation. There is a lack of evidence and data on specific standards and protocols designed for specific athlete categories. These points present the need for literature focused on HIIT protocols developed with specific athlete populations in mind.

On the other hand, youth athletes often face time constraints due to academic and extracurricular commitments, limiting the availability of extended training periods (Vacher et al., 2022). Short-term, high-intensity interventions, such as the 10-day HIIT protocol, offer a practical solution by delivering significant fitness improvements within limited timeframes (Atakan et al., 2021). Despite growing interest in optimizing athletic performance, female athletes, remain underrepresented in sports science research, especially basketball. Addressing this gap is critical for developing evidence-based training protocols tailored to their physiological and performance needs.

Against this background, the current study aims to determine the impact of a 10-day HIIT protocol on both aerobic and anaerobic capacity of U16 basketball athletes. By examining the effectiveness of this training regimen, the study hopes to provide valuable insights into optimizing performance for young athletes in this dynamic sport.

Materials and Methods

Study Participants

The study involved eight female U16 National Team basketball players, selected based on their participation in the national program. The study was conducted by ethical standards and was approved by the Ethics Commission (code: 2014/45) of the University for Business and Technology (UBT). The participants had a mean height of 172.9 ± 10.4 cm and a mean weight of 63.2 ± 10.8 kg. This group represents a competitive level of young athletes, providing valuable insights into the effects of the 10-day HIIT protocol on specific endurance in this group. All participants had at least two years of structured basketball training. Still, none had undergone a structured HIIT intervention before the study, ensuring that improvements were attributable to the protocol rather than prior familiarity. Since the group consists of high-level athletes in a specific sport, the number of participants is limited. However, to evaluate the effect size of the sample within the broader population, a G*Power analysis was conducted. The results are presented in Figure 1, with a detailed methodology explanation in the Statistical Analysis section below.

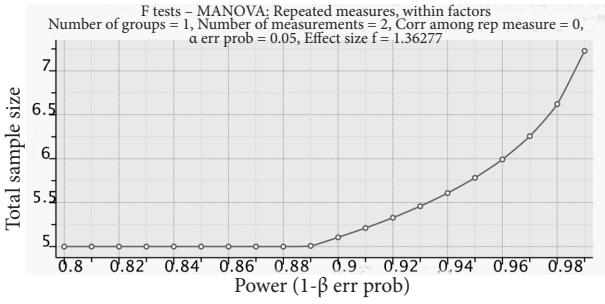

Fig. 1. Effect size of sample size on a targeted population (U16 National Team Basketball Players)

Table 1. Training Protocol Description

Day	Type	Features	Description	Work-rest	Total time	Energy system
1	HIT	Parkour with weight	The parkour consists of five stations. The first station includes Turkish get-ups, followed by lateral and forward swings at the second station. The third station features kettlebell windmills, while the fourth station involves throwing a medicine ball against the wall from both frontal and lateral positions. The final station focuses on backward and sideward ball dribbling with resistance bands for added pressure.	3:1	5×6	Aerobic
2	HIT	Bands, medicine ball	First round: The workout consists of partner exercises using a resistance band. One player holds the band and pulls with one hand while passing a medicine ball to the partner in front. This is done alternately with the left and right hands. The distance between players is determined by the length of the band. This round lasted 15 minutes, including rest breaks. The work-to-rest ratio, as shown in the following row, represents a standard method for structuring exercise and recovery intervals. For example, a 2:1 ratio indicates 20 seconds of work followed by 10 seconds of rest, while a 1:2 ratio corresponds to 10 seconds of work followed by 20 seconds of rest. Second round: The players work in pairs, facing each other, and throw the medicine ball in various ways, such as a two-handed chest pass, followed by alternating left- and right-handed passes. The distance between players is 3 ± 0.50 meters. This round also lasted 15 minutes, including rest breaks.	3:1 4:1 5:1 2:1 1:2 1:3		Aerobic Anaerobic
3	HIIT	Initiating the training a parkour with weight stations, and basketball dribbling	The parkour consists of seven stations, laid out around the basketball court. The first station involves skipping on stairs. The second station features forward jumps over low barriers, while the third station involves side jumps over low barriers. The fourth station includes passing over high barriers, requiring a wide range of motion in the lower body. The fifth station focuses on ball dribbling followed by shooting. The sixth station involves burpees, and the final station is a vertical medicine ball throw.	2:1 3:1 4:1 5:1 4:1 3:1	37	Aerobic Anaerobic
4	HIIT	Parkour with weight stations, and basketball dribbling	The parkour consists of seven stations, laid out around the basketball court. The first station involves skipping on stairs. The second station includes forward and side jumps over low barriers. The third station consists of side jumps over low barriers carrying the medicine ball. Fourth station involves passing over high barriers, requiring a wide range of motion in the lower body. The fifth station includes ball dribbling followed by shooting. The sixth station focuses on burpees, and the final station involves a vertical medicine ball throw.	2:1 3:1 4:1 5:1 4:1 3:1 2:1 1:1	35	Aerobic Anaerobic
5	HIIT	Competitive parkour with weight, runs, jumps and basketball dribbling	The parkour begins with a 14-meter curved run, followed by a triangle where the athlete changes direction and speed before proceeding to the next station, where ball dribbling begins. The entire parkour session lasts 35 minutes, including rest periods between shuttles. The load increases gradually, and depending on the intensity, athletes complete 13-16 rounds across the field. After the first three unloaded (no-weight) rounds, the athlete performs a 10-second skip in place with band resistance before resuming running. Following the fifth round, the athlete carries a 6 kg kettlebell during the initial running line. After the eighth round, the athlete jumps at every corner of the triangle (for agility) following the curved run. After the tenth round, the athletes complete a round without any weight.	1:2 1:3 1:4 1:5 1:1 2:1 3:1 4:1 5:1 1:3 1:4 1:5	35	Anaerobic
6	Tabata	Free or body weight exercises	Four Tabata songs (pre-recorded audio tracks with interval cues) are applied, with each song consisting of 8 work rounds. For each song, four movements are selected, meaning each movement is repeated twice during the 8 rounds. The first song focuses on dynamic, force-based cardiovascular load, with exercises including high skips, alternating leg raises forward and sideward, and burpees. The second song targets local endurance, incorporating bicycle sit-ups, crunches, skipping in a push-up position, and jumping in a push-up position. The third song emphasizes running-based cardiovascular load, where athletes perform side runs, forward-backward runs, side-forward-backward runs (all within 2 meters), and shuttle runs over a 3-meter distance. Finally, the fourth song centers on plyometrics, featuring jumps in place, side jumps, forward-backward jumps, basketball jumping technique, and various other jumps.	2:1	4×5	Anaerobic

Table 1 (continued)

Day	Type	Features	Description	Work-rest	Total time	Energy system
7	Tempo	Fartlek, acceleration, deceleration, Plyometrics	The tempo run consist of five linear lines to be covered by players in three rounds. First round; eight repetitions have been realized such as: first line (4m) max speed run, second line (2m) walk, third line (7m) max speed run, fourth line (2m) walk and the last line (5m) again max speed run. Second round; six repetitions have been realized such as: first line (4m) max speed run and jump, second line (2m) walk, third line (7m) max speed run backwards, fourth line (2m) walk and the last line (5m) max speed run. Third round; five repetitions have been realized such as: first line (4m) max speed run backward and jump, second line (2m) backward walk, third line (7m) max speed run backward and jump, fourth line (2m) walk and the last line (5m) jump and max speed run.	1:1 1:2 1:3 1:4 1:5	30	Anaerobic
8	Tabata	Runs	Four Tabata songs (pre-recorded audio tracks with interval cues) are applied, with each song consisting of 8 work rounds. For each song, four running techniques are determined. The first song focuses on shuttle runs, the second on forward-backward runs, the third on sideward runs, and the fourth on forward-backward-sideward runs.	2:1	4×5	Anaerobic
9	Tabata	Runs	Four Tabata songs (pre-recorded audio tracks with interval cues) are utilized, with each song consisting of 8 work rounds. For each song, four running techniques are designated. The first song focuses on shuttle runs, the second on forward-backward runs, the third on sideward runs, and the fourth on forward-backward-sideward runs.	2:1	4×5	Anaerobic
10	HIIT	Fast break	The players run the length of the entire field in groups of three. One player, positioned in the middle, passes the ball to the players on his right and left, who are running parallel to him. This exercise is repeated three times, after which the players change roles. In the next activity, the two players on the right and left hold the ball and pass it to the player in the middle, who continues running parallel to them. This is also repeated three times, with players changing roles afterward. These two types of drills are conducted over the distance of the field, with the players covering the field 1, 2, and then 3 times without stopping. The specific work-rest ratio for these activities can be found in the adjacent column.	1:1 1:2 1:3 1:4 1:5 1:6	35	Anaerobic

Data collection in this study was conducted following the Declaration of Helsinki and received approval from the University Ethics Committee.

Training Protocol

The HIIT training program was designed to enhance general and sport-specific endurance in basketball players, with a progressively adjusted training load implemented each daily. The program focused on developing general endurance through full-body exercises performed at 75-85% of maximal intensity. In the initial phase, work intervals predominated, with work-to-rest ratios ranging from 3:1 to 5:1. As the program advanced, the balance between work and rest became more equitable, with ratios shifting to approximately 2:1, 1:1, or 1:2.

Once full-body endurance was established, the intensity increased, and the work-to-rest ratios adjusted to approximately 1:3, 1:4, 1:5, or 1:6. This structured progression prepared athletes for the specific endurance demands of basketball, which involve repeated explosive sprints, high jumps, physical confrontations, and rapid transitions between offense and defense.

The training structure combined High-Intensity Training (HIT) to develop strength, HIIT for endurance, Tabata workouts to improve metabolic conditioning, and Tempo runs for speed and agility. This combination provided a comprehensive approach to enhancing aerobic capacity, anaerobic power, and basketball-specific skills. Parkour circuits with resistance exercises (e.g., kettlebell windmills, medicine ball throws) focused on dynamic strength and coordination, while partnered resistance band drills and competitive parkour routines simulated game conditions. Tabata sessions improved cardiovascular endurance and core strength, and tempo runs targeted acceleration, deceleration, and plyometric performance. Each session's work-to-rest ratios evolved from higher work intervals (e.g., 3:1) to ratios emphasizing recovery (e.g., 1:5), ensuring athletes adapted to increasing workloads while preparing for the intermittent nature of basketball gameplay.

Fast-break drills and court-length sprints with ball-passing exercises further emphasized teamwork and game-specific endurance under fatigue. This integration of diverse training modalities addressed basketball's physical and technical requirements, enabling athletes to sustain performance and recover rapidly during competition.

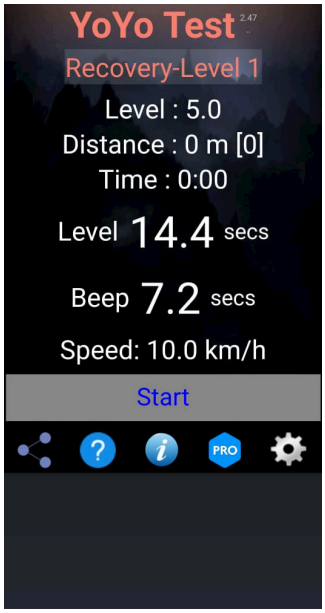

Fig. 2. Yo-Yo Test Settings

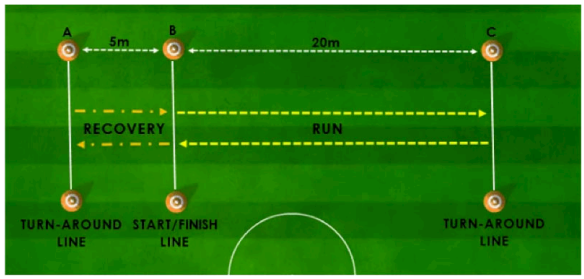

Fig. 3. Yo-Yo Recovery Test Level 1 stage

Table 1 displays the structure and key features of the 10-day HIIT training program implemented in the study.

Yo-Yo Recovery Test Level 1: The Yo-Yo Intermittent Recovery Test Level 1 (YoYoRL1) was administered to participants before and after the training camp to evaluate the impact of the HIIT protocol on their specific endurance.

In the YoYoRL1, participants begin from cone B and must sprint to cone C, reaching it before the subsequent beep. Afterward, they immediately return to cone B before the next signal. Upon reaching cone B, participants have a 10-second recovery period during which they jog to cone A and back to cone B. Participants are allowed two consecutive failed attempts, and a second failure results in elimination from the test. The level achieved is determined based on the number of completed shuttles, which is multiplied by 40 meters to calculate the total distance covered. The standardized table is used to correlate the number of shuttles completed to specific performance levels (Science for Sport, 2025). The YoYoRL1 typically lasts between 5 and 15 minutes (Science for Sport, 2025; Bangsbo et al., 2008). More details can be seen in the figure 2 and 3.

Statistical Analysis

In this study, several statistical methods were employed to analyze the data. The Shapiro-Wilk test indicated that the data were normally distributed ($p > 0.05$); therefore, parametric tests were employed in this study. Descriptive statistics, including the minimum, maximum, mean, and standard deviation, were calculated for body composition metrics (weight, body mass index, and body fat percentage), as well as for pre-test and post-test scores. These metrics provided an overview of the participants' characteristics and the changes observed before and after the training protocol. To assess the significance of differences between pre-test and post-test scores, a One-Way Repeated Measures Analysis of Variance (ANOVA) was performed. This test was used to determine whether there were significant changes in the Yo-Yo Intermittent Recovery Test Level 1 (YoYoRL1) scores following the 10-day intensive training protocol. The results of the ANOVA indicated a statistically significant difference ($F = 36.044$, $p = 0.001$), with a large effect size (Partial Eta Squared = 0.837), confirming that the protocol had a meaningful impact on Yo-Yo Recovery Test performance. All statistical analyses were conducted at the 0.05 significance level.

Based on the study model, which follows an experimental design with a single control group, the sample size was calculated using the G*Power 3.1.9.4 program. The analysis type A priori: Compute required sample size – given alpha, power, and effect size were applied. From the F tests group, the MANOVA: Repeated Measures, within factors method was selected. The effect size of HIIT training on general and sport-specific endurance, as measured by the Yo-Yo Recovery Level 1 test, was determined based on existing literature. Previous studies indicate a large effect size of HIIT on Yo-Yo Recovery Level 1, with an eta squared statistic of 0.61 (Yuan et al., 2024). This classification is further supported by the National Strength and Conditioning Association, which categorizes an eta squared value of 0.65 as moderate to large (McGuigan et al., 2017).

The input parameters for the analysis were as follows: Effect size f (1.36), α error probability (0.05), Power (1 – β error probability) (0.99), Number of groups (1), and Number of measurements (2). As shown in Graph 1, the total sample size of the study (8) achieved a statistical power of 0.99, indicating a high level of reliability.

Results

Table 2 shows significant differences in body composition variables between pre- and post-test conditions, with increases observed in weight ($p = .039$, $\eta_p^2 = .478$) and BMI ($p = .025$, $\eta_p^2 = .538$), indicating moderate to large effect sizes. However, changes in body fat percentage were not statistically significant ($p = .329$, $\eta_p^2 = .136$), suggesting that the observed weight gain resulted from increased glycogen storage and temporary muscle water retention rather than fat accumulation. This is a common short-term physiological response to intensified training.

The table shows a significant improvement in YoYoRL1 test performance from pre-test to post-test, with a mean difference of 2.3 ($p = .001$, $\eta_p^2 = .837$), highlighting a large effect size and strong statistical significance in the results. Although there are no statistically significant correlations ($p > 0.05$), the tendency toward a positive correlation between pre-test and post-test results suggests that athletes who performed better in the pre-test generally maintained their

Table 2. Body Composition Descriptives

Variables	Test time	Min	Max	$\bar{x} \pm S$	$\bar{x}$ diff	F	Sig	η_p^2
Weight (kg)	Pre	45.6	78.9	63.2 ± 10.8	1.1	6.411	.039	.478
	Post	47.4	79.3	64.3 ± 10.6				
Body Mass Index (kg/m²)	Pre	17.6	24.8	20.9 ± 1.9	0.5	8.153	.025	.538
	Post	18.3	25.1	21.4 ± 1.9				
Body Fat (%)	Pre	13.7	27.7	20.8 ± 5.1	-0.6	1.099	.329	.136
	Post	13.0	26.2	20.2 ± 4.1				

Greenhouse-Geisser: 1.000. The mean difference is significant at the .05 level. b. Adjustment for multiple comparisons: Bonferroni.

Table 3. One-Way Repeated Measures ANOVA

Test	Factors	Min	Max	$\bar{x} \pm S$	$\bar{x}$ diff	F	Sig	η_p^2	Correlations	
									R	P
YoYoL1	Pre-test	12.0	15.4	14.2 ± 1.23	2.3*	36.044	.001	.837	.577	.134
	Post-test	14.5	17.8	16.5 ± 1.17						

Greenhouse-Geisser: 1.000.The mean difference is significant at the .05 level. b. Adjustment for multiple comparisons: Bonferroni.

Table 4. Correlations between YoYoL1 test and body composition features

Tests		Sig	Weight		BMI		Fat Percentage	
			Pre	Post	Pre	Post	Pre	Post
YoYoL1	Pre-Test	R	-.733*	-.793*	-.552	-.628	-.654	-.625
		P	.038	.019	.156	.095	.079	.098
	Post-Test	R	-.723*	-.732*	-.460	-.439	-.570	-.494
		P	.043	.039	.252	.276	.140	.213

relative performance in the post-test, indicating consistency in performance development across both assessments.

The table shows a significant negative correlation between weight and YoYoRL1 scores in pre- and post-test conditions ($p < 0.05$), indicating that higher body weight is related to lower performance. While BMI and fat percentage, as components of body composition related to weight, also show negative correlations with YoYoRL1 scores, these relationships are not statistically significant ($p > 0.05$), suggesting that weight may have a more direct or pronounced effect on performance than its derived measures. Notably, the correlation rates remain consistent between the pre- and post-test results, even with significant changes in body composition and YoYoRL1 performance.

Discussion

This study aimed to evaluate the effects of a 10-day High-Intensity Interval Training (HIIT) protocol on the specific endurance of U16 female basketball players. The results indicated that the protocol effectively improved the participants' specific endurance, as evidenced by significant improvements in the Yo-Yo Intermittent Recovery Test Level 1 (YoYoRL1) scores.

Before the training, participants demonstrated a pre-test YoYoRL1 score of 14.2 ± 1.2, which increased to 16.5 ± 1.2 after the 10-day concentrated training protocol. This improvement was statistically significant ($F = 36.044$, $p = 0.001$) with a large effect size (Partial Eta Squared = 0.837), suggesting that the HIIT program enhanced the participants' ability to perform intermittent high-intensity efforts. The increase in YoYoRL1 scores aligns with previous research indicating that HIIT improves aerobic and anaerobic capacity, which are essential for the repetitive high-intensity demands of basketball (Shamim, 2021; Tabata et al., 1996).

The slight increases in weight and body mass index (BMI) and a minor reduction in body fat percentage, observed in this study may indicate short-term physiological responses to intensified training. Expectations include increased glycogen storage and temporary muscle swelling, rather than substantial muscle hypertrophy, which generally requires longer resistance training (Murray & Rosenbloom, 2018; Krzysztofik et al., 2019). Enhanced muscle glycogen storage is a well-documented response to endurance training, improving energy availability during exercise (Murray & Rosenbloom, 2018). This adaptation is particularly beneficial in basketball, where repeated sprints and rapid direction changes require immediate energy replenishment, delaying the onset of fatigue and sustaining performance across multiple quarters. Additionally, although substantial muscle hypertrophy is unlikely in just 10 days, neuromuscular adaptations and temporary muscle water retention may contribute to small increases in body mass (Murray & Rosenbloom, 2018; Uniqgene, 2025). These possible changes could positively influence the athletes' body weight-to-performance ratio, a critical factor in maximizing performance, as a favorable ratio allows athletes to generate more power relative to their body weight, improving their

efficiency in explosive movements like sprints, jumps, and physical confrontations on the basketball court (Simplifaster, 2025).

The observed improvements in specific endurance and body composition further support the relevance of incorporating HIIT into basketball training regimens, especially for youth athletes who face time constraints and require efficient, impactful training protocols. Despite the limited duration of the training program, the participants demonstrated significant gains (see table 3) in endurance, which could translate to improved performance during basketball games, where sustained high-intensity efforts and quick recovery are critical (Edwards et al., 2018). Additionally, a significant negative correlation was found between weight and YoYoRL1 scores in pre- and post-test conditions, suggesting that higher body weight is associated with lower endurance performance. While BMI and fat percentage tended to negatively correlate with YoYoRL1 scores, these relationships were weaker than the correlation with weight. This suggests that total body weight, regardless of composition, may be a more influential factor in endurance performance than fat percentage alone, possibly due to the increased energy demands of carrying additional mass during high-intensity efforts (NSCA, 2017).

This section shows HIIT training was applied with high frequency and intensity. Consequently, this training protocol's effect size on general and sport-specific endurance was substantial. However, despite the high training frequency and intensity, further analysis is needed to enhance the study's accuracy and strengthen its contribution to the existing literature.

Although specific Yo-Yo Intermittent Recovery Level 1 (YoYoRL1) test scores for U16 female basketball players are scarce in the current literature, general normative data for female team sport athletes are available: Elite (>Level 17.5), High level (Level 16.6–17.5), Good (Level 15.6–16.5), Average (Level 14.6–15.5), Below Average (Level 13.1–14.5), and Very Poor (<Level 13.1) (Wood, 2018 ; Bangsbo et al., 2008; Topend Sports, 2025). In our study, participants had a pre-test Yo-Yo IR1 score of 14.2 ± 1.2, which improved to 16.5 ± 1.2 after the 10-day intensive training protocol. Based on the normative data, the participants' initial performance was relatively low. This substantial improvement can be explained by the principle that the lower an athlete's initial motoric level, the easier it is to achieve significant gains. In contrast higher initial levels require greater effort to yield improvements. As a result, the large effect size observed in this study can be attributed to the participants' relatively low starting point.

The present study highlights the importance of sport-specific endurance training, particularly through HIIT, for enhancing basketball performance. By mimicking the intermittent, high-intensity demands of the sport, HIIT optimizes both aerobic and anaerobic systems, helping athletes to better handle the physical stressors of basketball. Moreover, using the Yo-Yo Intermittent Recovery Test Level 1, a reliable field test for aerobic capacity, provides a valuable tool for assessing changes in endurance and guiding training adjustments (Schmitz et al., 2018; Bangsbo et al., 2008). These findings reinforce the importance of incorporating structured HIIT programs into basketball training to enhance endurance performance efficiently. However, future studies should explore long-term adaptations and individualized training responses, particularly in female athletes, to optimize training interventions further.

The novelty of this study lies in several aspects. First, it demonstrates the effectiveness of a short-term intervention, providing meaningful results in just 10 days. Secondly, it offers specific and standardized data for a defined population (U16 female basketball players). Thirdly, the study introduces a structured HIIT protocol that can be adapted to various athletic populations, regardless of differences in body composition or motor abilities, by adjusting the work-to-rest ratio while maintaining consistent training load principles.

Conclusions

This study demonstrates the effectiveness of a 10-day High-Intensity Interval Training (HIIT) protocol in enhancing the specific endurance of U16 female basketball players. The significant improvements in Yo-Yo Intermittent Recovery Test Level 1 (YoYoRL1) scores highlight HIIT's ability to improve aerobic and anaerobic capacity—crucial components of basketball performance. Additionally, slight increases in body weight and BMI, alongside a minor reduction in body fat percentage, suggest short-term physiological adaptations such as increased muscle glycogen storage and transient water retention, potentially enhancing the body weight-to-performance ratio.

A key consideration is that participants had relatively low initial test scores, likely contributing to the large effect size observed. This aligns with the principle that athletes with lower baseline fitness levels tend to experience greater relative improvements, whereas those with higher initial levels show smaller gains.

Moreover, the scarcity of normative data for the YoYoRL1 test in U16 female basketball players underscores the significance of our findings. Establishing normative data in future research would allow for better benchmarking of endurance performance and the refinement of training protocols tailored to female youth athletes. This study provides valuable insights for coaches and the broader research community, helping to bridge this gap and inform future training methodologies.

Limitations

This study has several limitations that should be considered when interpreting the findings. One of the main limitations is the small sample size of eight U16 female basketball players, which restricts the generalizability of the results. A larger, more diverse sample would allow for stronger statistical conclusions and broader applicability. However, as shown in Graph 1, a G*Power analysis indicated that the total sample size (n = 8) achieved a statistical power of 0.99, demonstrating high reliability in detecting significant effects.

Additionally, the absence of a control group limits the ability to determine whether the observed improvements were solely due to the HIIT protocol or influenced by external factors such as individual motivation, prior conditioning, or natural performance fluctuations. Future studies should incorporate a control group to enhance the validity of findings and provide a clearer understanding of the true impact of the intervention.

Another limitation is the specificity of the participant group, as all athletes were members of the U16 national basketball team. This homogeneity means that the results may not directly apply to athletes from other age groups, fitness levels, or sports. Moreover, the short duration of the intervention (10 days) provides insights into the immediate effects of HIIT but does not capture potential long-term adaptations or retention of performance improvements. Future research should explore the sustained effects of HIIT over extended periods and assess its impact on muscle hypertrophy, neuromuscular adaptations, and injury prevention. Additionally, studies should compare HIIT's efficacy against other conditioning methods in basketball to determine optimal training strategies for youth athletes.

Lastly, uncontrolled external factors such as individual differences in recovery, sleep, nutrition, and motivation may have influenced the results. While this study provides valuable insights into the potential benefits of a short-term HIIT program for young female basketball players, addressing these limitations in future research—by incorporating larger and more diverse samples, control groups, and long-term assessments—will enhance the reliability and applicability of the findings.

Conflict of interest

There is no potential conflict of interests declared by the authors

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Оптимізація результативності: Вплив 10-денного протоколу високоінтенсивного інтервального тренування на спортивну результативність молоді

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 10 с., 4 табл., 3 рис., 30 джерел.

Мета дослідження. Мета цього дослідження полягала у вивченні впливу 10-денного протоколу високоінтенсивного інтервального тренування (ВІІТ) на специфічну витривалість баскетболісток вікової категорії до 16 років, з акцентом на поліпшення показників аеробної та анаеробної здатності та результативності Йо-Йо тесту переривчастого відновлення рівня 1 (Yo-Yo Intermittent Recovery Test Level 1, YoYoRL1).

Матеріали та методи. У дослідженні взяли участь вісім баскетболісток віком до 16 років, які виконували 10-денну програму ВІІТ, розроблену для підвищення загальної та спортивно-специфічної витривалості. Аналіз показників перед початком і після завершення тренувань включав вимірювання параметрів композиції тіла (вага, ІМТ, відсоток жирової маси тіла) та виконання тесту YoYoRL1 для визначення змін у результатах. Програма тренувань передбачала застосування різних методів ВІІТ, зокрема комплексні вправи для всього тіла, колові тренування з паркуру та спеціалізовані баскетбольні вправи із поступовим коригуванням співвідношення періодів навантаження та відпочинку.

Результати. Результати дослідження показали суттєве покращення результативності тесту YoYoRL1 від передтестового до післятестового етапів, з підвищенням середнього балу учасниць з 14,2 ± 1,2 у передтестовому періоді до 16,5 ± 1,2 у післятестовому періоді ($p = 0,001$, $\eta_p^2 = 0,837$), підкреслюючи великий розмір ефекту та сильну статистичну значущість результатів. Аналіз композиції тіла виявив незначне збільшення ваги (64,3 ± 10,6 кг на післятестовому етапі) та невелике зменшення відсотка жирової маси тіла (20,2 ± 4,1 % на післятестовому етапі), що вказує на сприятливі зміни в м'язовій масі та розподілі жиру в організмі.

Висновки. Впровадження 10-денного протоколу ВІІТ сприяло значному поліпшенню специфічної витривалості та аеробної здатності у баскетболісток вікової категорії до 16 років, що свідчить про ефективність короткострокових

ВІІТ-інтервенцій щодо підвищення результативності юних спортсменів. Отримані результати підтверджують доцільність використання ВІІТ з метою оптимізації витривалості та відновлення в баскетболі, що має значення для розроблення ефективних за часом тренувальних протоколів для молодих спортсменів. Однак невеликий розмір вибірки та коротка тривалість дослідження обмежують можливість узагальнення зазначених результатів, що вимагає подальших досліджень із залученням більших когорт. Подальші дослідження слід зосередити на вивченні довгострокових ефектів таких тренувальних програм та їх застосовності у різних групах спортсменів.

Ключові слова: ВІІТ, Йо-Йо тест переривчастого відновлення, витривалість, жіночий баскетбол, юні спортсмени.

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